Welcome to Stanford!

Welcome to Stanford University! We are research scientists and staff members who work in Stanford’s Center for Computational, Evolutionary and Human Genomics (CEHG), which is primarily a research program that brings together the work of 40 professors and their labs across campus. We are thrilled to meet you and to tell you a bit about what we love about college life, science jobs, and the Stanford Campus.

This lab tour event is part of CEHG’s new outreach program, which is geared toward educating and inspiring the next generation of scientists, especially those working in the field of genetics. Program participants also aim to enhance diversity among college students and professionals working in STEM (Science, Technology, Engineering, and Mathematics) fields. We hope you will find this resource packet helpful as you continue your high school education and look forward to your college experience. Today's activities will begin with a short orientation to Stanford's campus and college life, which will be followed by lunch and a panel discussion, where scientists will discuss their work, paths to science, college experiences, and advice for college success. Then, we will break into small groups and begin lab tours where we will visit three different labs on campus and watch presentations on the fun and groundbreaking work being done in those labs. Finally, all tour groups will reconvene in Clark Center, so we can have a little social time before heading back to the buses on Palm Drive.

— Katie Kanagawa, PhD. Stanford CEHG Communications and Outreach Manager

What does college have in store for you?

The college experience is an adventure that offers virtually unlimited opportunity for learning. Most colleges offer a diverse range of majors, including sciences, social sciences, humanities, engineering, and arts. If you opt for a science major, you will follow your curiosity by asking questions about the natural world, and using the scientific method you will answer those questions and make new discoveries. Between course work, research, outreach, and study abroad, college offers many opportunities to participate in the scientific process and to launch a career as a member of the scientific community.

Why study science?

Science is a creative process in which we follow our own human curiosity about the world to generate hypotheses and predictions, and then apply rigorous experimental methods to test these predictions. Sometimes scientists just record natural phenomena and compare their observations to their models (for example, a physicist might use a detector to measure light given off by supernovae), and other times they might manipulate experimental variables themselves (such as a botanist planting crops at different densities to study how survival and growth rate may change). But the scientific method is as powerful of a process for physics and botany as it is for your day-to-day life decisions. So, in that sense, we do not have a choice to study science or not: Life is Science. Everyone uses a rudimentary sort of science when deciding what route to take to school or when acquiring a new skill.

What we do have a choice in though, is whether or not we make science a career. Science as a career can be exhilarating. A career scientist makes the commitment to be a lifelong learner and teacher, and to rigorously apply the scientific method to solve problems important to humanity or that broaden our understanding of our world and universe. When things are going well, a scientist is rewarded personally and respected socially for following their intellectual pas-
sions – but for many scientists the process of participating in the scientific mission is its own reward. Science does not just accommodate a diversity of thought, it actively requires a diversity of thought. “Why study science?” is a question that many scientists ask themselves every day. And for many of us, the ability to live by the philosophical stance “teach others as you would like to be taught” is one of our greatest motivators.

Why do research?

If you ask scientists about why they do research, you will likely hear a wide variety of answers. A human geneticist might study a particular disease because they have been affected by it. A roboticist might tell you that they are fascinated by the way machines work, and a physicist might describe the experience of hearing about black holes in grade school and being hooked ever since. Ultimately, all scientists are curious about how things work, and have a desire to use repeatable experiments to test their hypotheses and build on the ever-growing body of human knowledge.

Research can be incredibly rewarding when it is going well. On any given day when you walk into the lab, it is possible that by the time you leave hours later you will have discovered something new that no one has ever known in the entire history of humankind. On the flip side, some days scientists walk into work only to discover they made a crucial error, or that a new experiment challenges their understanding of their own work. Those of us who love research embrace the idea that it is a process that inherently challenges us to face the unknown.

What types of opportunities are available for undergrads?

The types of opportunities available for undergraduates will vary from school to school but there are usually lots of ways to get involved. The best way to get started is to ask your TAs, professors, academic advisors and student support staff members what they recommend for getting involved in research. Chances are there will be ways for you to do research during the term or during the summer, as a research assistant (sometimes as a part of a paid work-study!), as part of a class, as a class itself, in campus labs, in the field, in the library or even on other campuses.

Research experiences can vary from assisting a graduate student or researcher with an ongoing project to taking on your own independent project or honors thesis. You’ll probably want to start with something small, explore your options and maybe pick a larger project when you know what you like and as you look towards a senior thesis. Many science labs have opportunities for undergraduates to get involved (often working more closely with a graduate student or postdoctoral fellow than the head of the lab), but often this requires contacting the professors or researchers directly.

Summer can be a good time to try doing research since you don’t have the pressures of classes; in this case, look out for “REUs” or “research experiences for undergraduates” which are funded summer projects at universities around the country. This can be a great way to expand your network and knowledge of other schools as well as get a taste for research in a project designed for undergraduates!

A good tip for getting a research position as an undergrad is to make sure whoever you reach out to knows that you are willing to work for college credit or as a volunteer for a semester or two – often in academic labs funding can be very tight, so a willingness to learn as a volunteer at the beginning can help you get your foot in the door and pave the way to a paid position soon after. If your financial constraints require you to be paid you should visit your college’s career center and ask if there are supplemental funds that could support your research time in the lab.

What types of research exist?

Scientific research often differs from the type of research that high schoolers complete in that scientists are often asking questions no one has ever answered before. In many high school research projects, you might be literally “re”-searching – delving into questions that others have explored and grappled with in the past. For example, a student might want to know what kinds of genes are mutated in cancer? They scroll through a few pages of search results, and read a Wikipedia article. This is “re”-search.

Junior scientists often start out mastering this type of research, and over the course of minutes or days or years, they transition into performing the other kind of research – the process of asking a question that does not have a known answer. Once they’ve “re”-searched this question and found out that gene \( X \) is mutated in tumor cells, now they are ready to ask a novel question – how do mutations in gene \( X \) cause cancer? From that targeted question, a kaleidoscope of downstream research possibilities exist, limited only
by the creativity of the researcher. The answers to these downstream questions might be found by writing programs on a computer (or not), by talking to people or sharing results with other scientists (or not), by using a model organism or a simulation (or not), by using objective rationality or following the deepest and quietest intuition.

Research is performed at academic universities, by the government, by private businesses, and by unaffiliated individuals. Research does not require any special letters after your name, a certain score on an IQ test, or anything like that. Research is simply the process of finding something out, and the best researchers have a passion for this process.

Types of colleges

Liberal Arts Colleges (e.g., The Claremont Colleges or Occidental College)

Liberal arts colleges feature small class sizes and a wide range of academic offerings, and typically encourage students to take a large number of courses outside their major to build up a broad base of knowledge and critical thinking skills in many fields. They typically offer BA and/or BS degrees, and often have fewer than 3,000 students.

The scientific research enterprise is often on a smaller scale at liberal arts colleges as compared to large universities. However, because there are usually very few graduate students at liberal arts colleges, it is often possible to get directly into research labs even as a first or second year student, so long as your academic performance is good and you are persistent! It is also often possible to design your own curriculum that combines interests (for example, you could design a major that combines computer science and biology, or two seemingly disparate fields, like biology and dance). Professors offer hands on, one-on-one attention at liberal arts colleges as the ratio of students to professors is typically much lower than at larger universities and colleges. Many liberal arts colleges have high tuition rates, but may also offer generous financial aid packages, sometimes including grants that do not need to be paid back upon graduation.

Research Universities (e.g., Stanford University or UC Berkeley)

As you might have guessed, research universities focus much more on research than teaching. Research universities typically offer BA, BS, MS, and PhD degrees, and may also offer other professional degrees in business, law, and other fields. They usually have a large number of students, often more than 10,000.

A large portion of the best, most cutting-edge research is performed at research universities, and professors at these schools likely teach few classes and rely heavily on teaching assistants to fill in the gaps. As a result, the best way to get close contact with your professors is to become involved in research. Often, classes in these universities will contain hundreds of students and you will only get into smaller classes that offer more contact with faculty as an upper division student in more specialized classes. These universities usually do offer many opportunities for undergraduates to become involved in research either through courses, summer internships or honors thesis programs. Public research universities, such as those in the UC system, may offer in-state tuition, which could be substantially lower than competing private schools. Some private universities, like Stanford, offer generous aid to admitted students, but have higher tuition than state universities.

Teaching Universities (e.g., San Francisco State University or Santa Clara University)

Teaching universities focus very heavily on undergraduate curriculum instead of conducting graduate-level research. They typically have 5,000 students or more, and may offer BA, BS, and MS degrees. Class sizes vary widely at teaching universities, with some having many large lectures and others having small class sizes like some liberal arts colleges.

Benefits of this type of environment may include more personalized attention and unique teaching styles, because professors’ primary job at teaching universities is to teach. However, scientific research is likely to be performed on a smaller scale than at a research university. This limitation can be overcome by enrolling in summer research programs at other research universities – most of which are paid positions. Moreover, similar to liberal arts colleges, there are likely to be a few research opportunities on campus, and it may be easier to actually meet your professors one-on-one and ask to join their lab at a teaching university than a research university. Some teaching universities, such as those in the California state system, are more affordable than most other colleges. Private teaching universities are likely to have much higher tuition, but like other private schools they may offer substantial financial aid.

Scientific careers

Academic research

This type of research is what we at CEHG have the most experience with. It takes place at an academic institution (such as Stanford or another university), and is usually funded through grants, which researchers apply for. Sometimes there
is a bit more freedom to explore high-risk topics in academic research, since researchers aren't necessarily restricted to topics that are related to a company's interests (see industry research section), but academic researchers are also at the mercy of their funding agencies and funding can often be tight.

Industry research

This is research done in the setting of a company (for instance, Google, Illumina, 23andme, etc.), usually on a topic directly related to the company's mission. For example, Illumina employees are likely doing research on how to make their next DNA sequencing instrument better while 23andme employees may use the company's genetic data to predict individuals' ancestry. Industry research often does not rely on grant funding, but it can sometimes offer less intellectual freedom than academic research, since they must be related to the company's goals and the end goal is often to make a profit.

Science writing

This involves writing to convey scientific information, often to the general public or other people without a specific scientific background. Science writing requires both an understanding of the scientific subject and also the ability to explain the subject in a way that anyone can understand. This is particularly important for helping others to understand the importance of scientific research and sharing important discoveries so that the general public can understand their significance.

Government research

This type of research is performed at a government institution. In science research, this is often an organization like the NSF (National Science Foundation), NIH (National Institutes of Health), or NOAA (National Oceanic & Atmospheric Administration). Research in government is often focused on projects thought to be of national importance (e.g. the Human Genome Project, the Personalized Medicine Initiative, defense against bioweapons, or monitoring the impact of climate change on various organisms).

Science education & outreach

Science education comes in many forms, from formal education in schools and universities to informal education through museums and community outreach programs. Jobs for science educators include teachers, museum curators, and outreach coordinators.

Advice on admissions or succeeding in college

1. If possible, visit the schools you are considering attending – make sure they are places where you would be happy for four years.
2. Ask yourself what personal resources or experiences you need to be successful during your college experience and do some research to find the schools that feel like they could be a good match. Would you be happier at a small or a large school? Does location matter to you? How much 1:1 time with your teachers would you like? Is music, sports, or some other activity a priority?
3. Remember that you do not need to go to a top-rated university to succeed. Some colleges may offer more opportunities than others, but many scientists (including many of us here at Stanford!) did not attend fancy colleges.
4. Admissions offices are looking to get a sense of who you are. Would you make a good classmate, roommate, member of the university community, etc.? Therefore, it’s very important to make sure your essays are about you! Let them know what you’re passionate about and why.
5. Succeeding in college: Go to office hours! Talk with your professors! College is all about being self-motivated in the process of self discovery and exploration of our world. There are a lot of resources and people to help you, but you’ll generally need to seek them out – they won’t necessarily find you. For many students of color, first generation students, or women in quantitative fields there can be additional social challenges to overcome during the college experience. Know that you are not alone, and reach out to those around you including peers and mentors to get over the hurdles that arise.
Additional resources

1. Stanford offers many summer programs for high schoolers:
   - [http://oso.stanford.edu/programs/audiences/5-high-school-students](http://oso.stanford.edu/programs/audiences/5-high-school-students)

2. Summer research programs for undergraduates are available at Stanford and many, many other universities and colleges:

3. Stanford “Splash” has tons of classes designed with the idea of getting into college and how to succeed once a quarter at Stanford. Financial aid is available, and since the students are local this is a great way to have an in depth weekend to discuss these issues.
   - [https://stanfordesp.org/](https://stanfordesp.org/)

4. KQED has a great series of short videos on different careers in science, check it out!

5. Many academic fields (such as biology and economics) as well as large companies (such as Facebook or Kaiser) increasingly rely on sophisticated data analyses performed by programmers. Interested in gaining some programming skills? Check out one of these websites:
   - [https://www.codecademy.com/](https://www.codecademy.com/)

6. If you have further questions, don’t hesitate to contact a CEHG graduate student! You can find email addresses for most of us online. We are eager to hear from you and to put you in touch with more resources that can help get you started on your journey towards college.